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Identification of Promising Resource Recovery Alternatives for Greensboro, High Point, and Winston-Salem, North Carolina

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Prepared for

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This report was prepared for the Triad Region of North Carolina, (Greensboro, High Point, and Winston Salem) subsequent to a three volume Phase I Preliminary Feasibility study of resource recovery potentials. This study investigates the potential role of resource recovery as a primary element of a solid waste management strategy and identifies six technically feasible resource recovery alternatives. In developing these options, three generic technologies were considered: mass burning combustion, coarse RDF production/dedicated boiler, and modular combustion. Although eight prospective customers for waste-derived energy were interviewed, only four present probable markets.

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Solid Waste

EPA

A TECHNICAL ASSISTANCE PROGRAM REPORT

IDENTIFICATION OF PROMISING RESOURCE RECOVERY ALTERNATIVES FOR GREENSBORO, HIGH POINT, AND WINSTON-SALEM, NORTH CAROLINA

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RESOURCE RECOVERY AND CONSERVATION PANELS

SEC. 2003. The Administrator shall provide teams of personnel, including Federal, State, and local employees or contractors (hereinafter referred to as "Resource Conservation and Recovery Panels") to provide States and local governments upon request with technical assistance on solid waste management, resource recovery, and resource conservation. Such teams shall include technical, marketing, financial, and institutional specialists, and the services of such teams shall be provided without charge to States or local governments.

This report has been reviewed by the Project Officer, EPA, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

Project Officer: Elmer G. Cleveland

U.S. ENVIRONMENTAL PROTECTION AGENCY

TECHNICAL ASSISTANCE PROGRAM REPORT SERIES

IDENTIFICATION OF PROMISING RESOURCE RECOVERY ALTERNATIVES FOR GREENSBORO, HIGH POINT, AND WINSTON-SALEM, NORTH CAROLINA

Prepared for Office of Solid
Waste Management
U.S. Environmental Protection Agency, Region IV
Atlanta, Georgia

By
CSI Resource Systems, Inc.

June 1981

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PREFACE

This report was prepared for the Triad Region, North Carolina, under the Technical Assistance and Panels Program, which is conducted by the U.S. Environmental Protection Agency (EPA) to provide assistance to state and local governments. Technical assistance was provided in response to a request submitted to U.S. EPA Region IV by the Triad Region.

Resource Systems is a technical assistance contractor to the Office of Solid and Hazardous Waste, U.S. EPA Region IV. Under the terms of the Technical Assistance and Panels Program, all of Resource Systems' technical assistance activities on behalf of the Triad Region were paid for by EPA.

TECHNICAL ANALYSIS OF RESOURCE RECOVERY ALTERNATIVES

To investigate the potential role of resource recovery as a primary element of a solid waste management strategy for the cities of Greensboro, High Point, and Winston-Salem, North Carolina, an energy market survey was conducted, and six technically feasible resource recovery alternatives were identified. Each of these alternatives is based on a proven resource recovery technology that can process all or a portion of the available waste supply to produce usable energy in a form and quantity that fit the needs of potential energy buyers.

The estimates of the quantity of waste available to a resource recovery facility serving one or more of the cities are based on 1978 waste generation projections. In the absence of a waste sampling program, it was assumed that unprocessible waste amounts to 20 percent of total waste generation. The remaining 80 percent of waste was assumed to be processible in a recovery facility, on the basis of visual inspection of waste by local officials and experience with other resource recovery projects. The resulting estimates of available waste supply are shown in the following table:

	Estimated Processible Waste Available		
City	TPD_5*	TPD_7**	Tons per Year
Greensboro	876	624	227,800
High Point	240	172	62,800
Winston-Salem	624	441	161,000

Technically feasible resource recovery alternatives were defined by:

- Identifying potential buyers for the energy that could be produced from all or a portion of the processible waste estimated to be available.
- Selecting resource recovery technologies that are compatible with the requirements of the potential buyers and the characteristics of the available waste.

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* Tons per day on a 5-day-per-week basis.

** Tons per day on a 7-day-per-week basis.

POTENTIAL ENERGY MARKETS

Eight prospective customers for waste-derived energy were interviewed regarding the size and variability of their energy demand; their ability to use recovered energy; their interest in resource recovery; and the availability of an appropriate site. Six of these concerns had previously been identified as promising candidates during the energy market survey performed in support of the October 1979, "Preliminary Feasibility Study of Resource Recovery for Greensboro, High Point, and Winston-Salem, North Carolina." As a consequence, follow-on interviews with these six concerns also addressed changes in their circumstances since mid-1979. From these interviews, the following four potential primary energy customers were identified:

- Lorillard Corporation in Greensboro (low-pressure steam and possibly electricity)
- North Carolina A&T University in Greensboro (low-pressure steam and possibly electricity)
- Hanes Corporation in Winston-Salem (low-pressure steam and possibly electricity)
- Greensboro Waste Water Treatment Complex (electricity).

Because of the apparent lack of a contiguous suitable site, A&T University can only be considered as a practical energy customer in combination with Lorillard. Hence, these four energy customers constitute the following potential markets: (1) Lorillard/A&T University; (2) Lorillard; (3) Hanes Corporation; and (4) Greensboro Waste Water Treatment Complex.

Of the four other possible energy buyers investigated, two -- Cone Industries and Reynolds Tobacco -- although technically promising candidates, were eliminated from further consideration because of their expressed lack of interest. The third, Procter and Gamble, was eliminated from further consideration based on its limited projected energy demand and its current commitment to displace expensive fossil fuels with low-cost woodwaste. Finally, Duke Power was eliminated as a customer for an electricity-only facility because of its current use of relatively low-cost fuels in its generating units (primarily coal and nuclear). However, Duke Power has indicated an interest in purchasing waste-derived electricity and thus was considered as a possible buyer of electricity from either a cogeneration

facility serving a process steam customer or an electricity-only facility producing energy in excess of the Greensboro Waste Water Treatment Complex's demand.

The four potential customers identified as promising share the characteristics described in the following subsections.

Interest in Resource Recovery. Although an expression of interest cannot be viewed as a commitment to purchase waste-derived energy, it was considered a prerequisite for a promising customer.

Technical Capability to Use Recovered Energy. Of the four potential customers, three currently use low-pressure steam (an energy product that can be recovered from solid waste) for process requirements and/or heating and cooling. Although average hourly steam demand is high for these three concerns, it is variable, particularly on a seasonal basis and during second and third shifts. Such fluctuations in steam demand are problematic for a resource recovery facility only producing steam for sale. By adding a turbine-generator to the system and producing electricity while extracting steam for sale (i.e., cogeneration), the energy recovery system can be operated at a relatively constant load. Hence, to attain the highest possible plant capacity utilization factor (and thereby maximize energy revenues), the concept of cogeneration was considered for the three process steam customers.

The Greensboro Waste Water Treatment Complex requires electricity. Its hourly and seasonal energy demand is high and continuous (24 hours per day, up to 365 days per year), indicating a potentially high capacity utilization factor for a resource recovery facility serving this customer.

Current Use of High-Cost Fuel. The three potential steam customers currently use either natural gas or No. 6 fuel oil. The Waste Water Treatment Complex will be purchasing electricity. Although electricity in this region is currently moderately priced, it is expected to increase in cost at a rate at least equivalent to the annual inflati rate.

Proximity to a Suitable Site. For two of the three potential steam buyers (Lorillard and Hanes), at least one vacant site of adequate size is potentially available close enough to the prospective customer to enable economic transportation of steam. As mentioned previously, no suitable sites were identified for a facility to service North Carolina A&T

University alone. For this reason A&T University and Lorillard were combined to constitute a single energy market, with a steam transmission line connecting the university to a recovery plant at Lorillard.

Because it is possible to tie in to the electricity grid at virtually any point, it is not necessary to secure a site contiguous to the electricity buyer. Therefore, site proximity to the Waste Water Treatment Complex is not an issue.

Proximity to Waste Source. Each potential market is close enough to a source of waste so that waste transfer operations are not necessary, assuming that the projects do not use waste from all three cities.

Stability. Each potential steam customer has been operating in the area for at least several years and appears to be in sufficient financial health to justify consideration as a long-term energy buyer.

TECHNICALLY FEASIBLE ALTERNATIVES

The estimated quantity of processible solid waste available and the energy requirements of prospective customers dictate both the size of a resource recovery facility and the form of energy produced. Because, in this case, the markets identified as promising could not use all of the energy that would be produced if all of the available tonnage in the region were processed, systems were sized according to market requirements, rather than available tonnage. While Duke Power represents a potential buyer of waste-derived electricity (either from a cogeneration plant servicing any of the process steam market candidates or excess power from a facility servicing the Waste Water Treatment Complex), the energy revenues that could be obtained from Duke would be relatively low because of its current use of low cost fuels. Consequently, as indicated in the section on "Economic Analysis of Resource Recovery Alternatives," it would not be practical from an economic standpoint to size the plants for optimal waste disposal and maximum electricity production. Rather, the plants are sized to achieve maximum economics while meeting primary energy market requirements.

To identify technically feasible resource recovery alternatives, the energy requirements of the four potential energy customers were compared with the technical characteristics of compatible, demonstrated technologies.

As a result, the following six resource recovery alternatives were defined:

1. A 625-TPD_7 (solid waste throughput) mass-burning system or a coarse refuse-derived fuel (RDF) system providing steam to Lorillard and A&T University and electricity to Duke Power.

2. A 1,000-TPD_7 (throughput) mass-burning system or a coarse RDF system providing steam to Lorillard and A&T University and electricity to Duke Power.

3. A 249-TPD_5 (throughput) modular combustion unit (MCU) system providing steam to Lorillard and electricity to Duke Power.

4. A 249-TPD_7 (throughput) MCU system providing steam to Lorillard and electricity to Duke Power.

5. A 178-TPD_5 (throughput) MCU system providing steam to Hanes and electricity to Duke Power.

6. A 310-TPD_7 (throughput) MCU system providing electricity to the Greensboro Waste Water Treatment Complex.

In developing these six alternatives, three generic resource recovery technologies were considered: mass-burning combustion; coarse RDF production/dedicated boiler; and MCUs. Each of these technologies either has been demonstrated commercially or is in the process of startup and thus has reasonably established operating parameters. Each is described below.

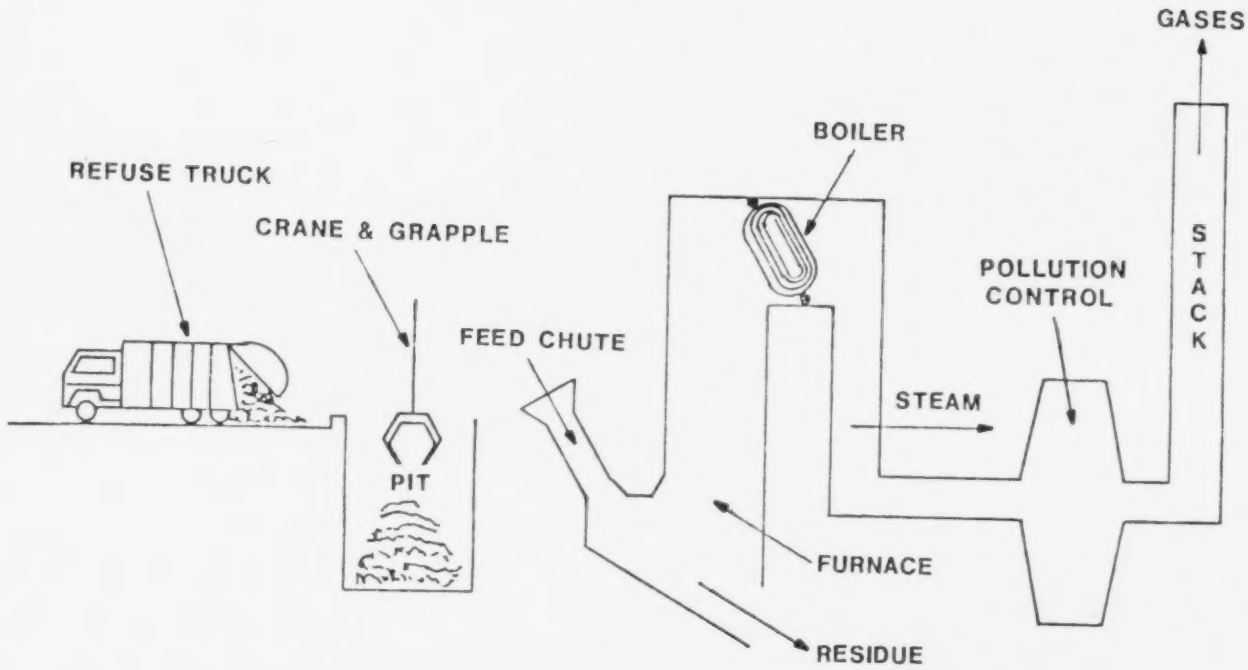
1. A Mass-Burning System to cogenerate steam and electricity.

Mass-burning systems that produce steam are now operating in several cities including Nashville, Tennessee; Saugus, Massachusetts; and Norfolk, Virginia. Mass-burning resource recovery systems can meet the needs of large steam customers for process or turbine-quality steam. Unlike MCUs, mass-burning systems are specially designed, field-erected units, which frequently employ proprietary grate and furnace designs. Individual boiler capacities range from 100 to 1,000 TPD. Hundreds of these units have been operating in Europe and Japan beginning in the mid-1960s. Today, there are eight such installations in the United States.

Figure 1 presents a simplified diagram of a mass-burning system. As shown in this figure, all of the waste received at the resource recovery facility is fed to the boiler, without any front-end processing or separation. Large facilities include concrete pits for storing solid waste so

FIGURE 1

MASS-BURNING SYSTEM



that energy can be produced on days when solid waste is not delivered. The waste is lifted from the pit with overhead cranes and grapples and loaded into feed chutes and onto the burning grates. When the waste reaches the grate system, it ignites and burns as it moves down the inclined grates. The air required for combustion is supplied through the bottom of the grates, as well as over the top of the burning waste mass. The gases generated during combustion exit upward through the boiler. The sidewalls of the furnace are frequently lined with water-filled tubes, which capture much of the heat from these gases prior to extraction of the remaining heat in the boiler tube banks following these tubes. The flue gases then enter electrostatic precipitators or baghouses for removal of particulate matter and are discharged to the atmosphere.

Residues from a mass-burning system are usually quenched in water and then passed under a magnet, which recovers magnetic materials for sale to the area's scrap markets. The mass-burning system produces ash that is dewatered to approximately 50-percent moisture, and, if well burned-out, is virtually free of combustible residue. This material is used in some European countries as road-bed material, construction material, or landfill cover. Hence, it may be possible to use this ash in the United States at some future time.

2. An RDF/Dedicated Boiler System, in which coarsely shredded solid waste is burned to cogenerate steam and electricity.

Process or turbine-quality steam requirements of large steam markets can be met by burning fuel prepared from solid waste in a specially designed (dedicated) boiler. Such a system has been operating in Hamilton, Canada, since 1973. For reasons similar to those that caused coal boiler designers to switch from mass firing to preparing coal prior to combustion (i.e., less energy loss, improved burnout, improved steam quality control, smaller furnace size), interest in this technology has increased. Today, plants using the coarse RDF concept are in startup in Akron, Ohio, and nearing completion of construction in Buffalo, New York. The fuel preparation and firing systems have been operating in Ames, Iowa, since 1974, as part of a coal/RDF cofiring installation using grate-equipped boilers.

The coarse RDF system is capable of processing large quantities of solid waste. This process differs from the mass-burning system in that incoming solid waste is processed into a fuel prior to incineration. Figure 2 presents a simplified diagram of a coarse RDF system. The waste passes through a "sizing circuit" -- a combination of a mill and a sizing screen. Waste is recirculated through this circuit until all of the material is of uniform size. The coarse RDF particles are passed under a magnet to remove products before incineration, thus enhancing their value in the secondary metals market. The prepared fuel enters a fuel surge bin and a fuel feed system.

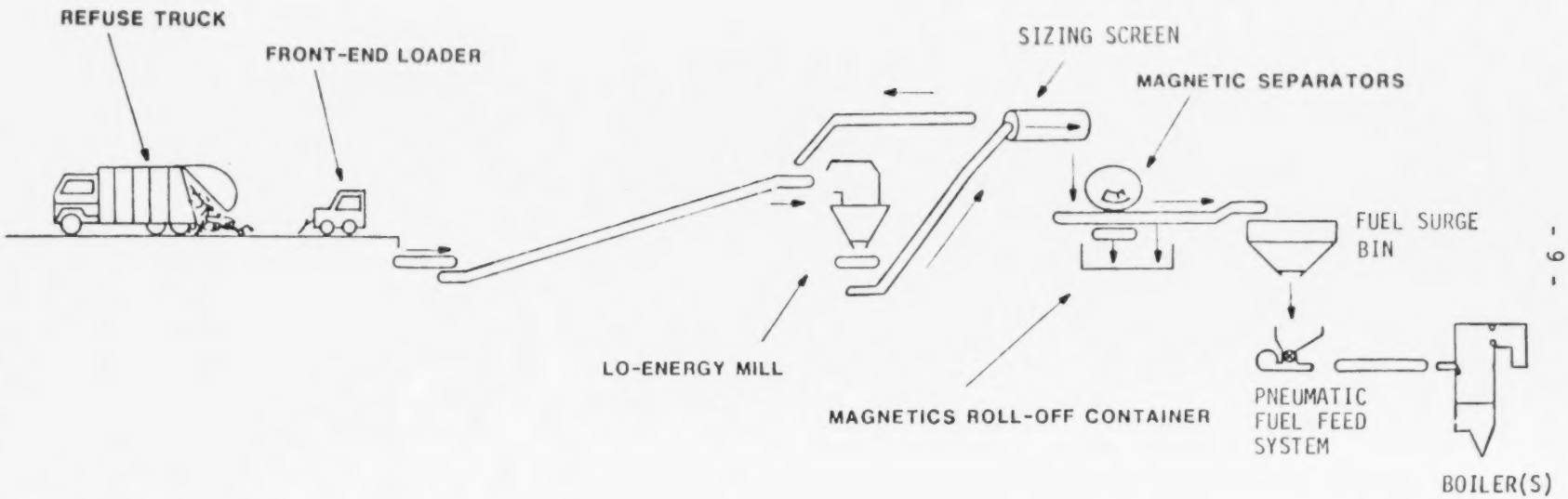
The coarse RDF is then burned in spreader-stoker-equipped boilers to raise steam. In these boilers, unlike mass-burning boilers, the solid waste is projected into the boiler, where much of it burns in suspension, and the remainder falls to a grate system for final combustion.

Combustion air enters with the fuel, under the grate, and above the fuel bed. Because there is relatively little fuel in the boiler at any time, combustion can be closely controlled, and a unit can respond to load changes. Also, improved air and combustion control should enable units of this type to operate with less total air than mass-burning units, thus reducing heat losses from the stack gases and permitting installation of smaller air pollution control equipment.

The spreader-stoker boiler has a higher thermal efficiency than the mass-burning boiler and thus yields more energy per ton of waste input. However, this advantage can be lost easily if too much fuel is lost in fuel preparation. In addition, the initial capital cost for a coarse RDF system is usually lower than that for a mass-burning system of equivalent size because fewer boilers are required. Even with the addition of processing equipment to this system, total capital costs are still below those for a mass-burning system. The disadvantages of the coarse RDF system are the added operating expenses of, and the risks associated with, the front-end shredding. The mechanics of handling shredded waste are not yet fully standardized, so that some startup delays could be encountered.

FIGURE 2

COARSE RDF-FIRED SYSTEM



3. An MCU System to produce steam and/or electricity.

Steam markets with low demand (20,000-80,000 pounds of steam per hour) and, thus, small processing requirements for solid waste (100-400 TPD), can be served by MCUs, which are pre-engineered, factory-assembled systems. MCUs equipped for solid waste processing, energy recovery, and continuous ash removal are available in individual unit sizes ranging from 10 to 75 TPD.

Figure 3 provides a simplified diagram of an MCU. As shown in this figure, waste is delivered to the resource recovery facility, onto a concrete unloading floor. Unprocessible materials (e.g., large metal objects, water heaters, rugs) are removed and placed in residue containers for sale as scrap or for disposal in a landfill. A front-end loader is used to push the remaining solid waste into a hopper, and a hydraulic ram-feeder moves the waste into the incinerator's lower chamber where it is partially burned. The heat released provides the energy needed to dry and gasify the remaining waste. The carbon-monoxide-rich smoke leaves the top of the lower chamber and enters the secondary chamber; there, more air is added, and the gases are burned to completion. As the hot gases exit the secondary chamber, they pass through a heat exchanger, where the heat in the exit gases is converted to steam. The stack gases are then discharged to the atmosphere.*

Ash consisting of glass, stone, metals, inert solid waste, and uncombusted organics is moved from the bottom of the lower chamber into an ash disposal system. A magnet that recovers magnetic metals for sale to the secondary metal market can be installed. The remaining ash is loaded into a truck for disposal at a landfill.

The following subsections describe the resource recovery alternatives developed to serve the four primary markets identified as promising.

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* No MCU currently in operation uses a pollution control device (particulate emission control is usually provided for in the design of the unit). However, increasingly stringent air pollution regulations will likely require the installation of such devices on MCUs.

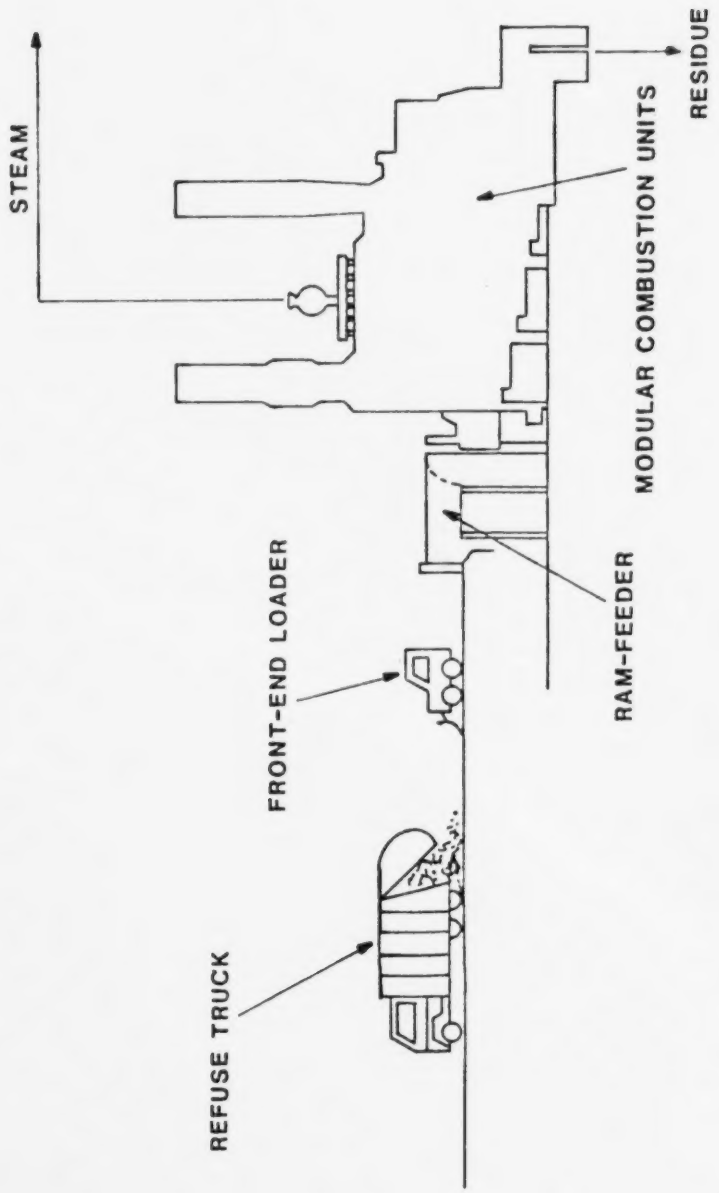


FIGURE 3
MODULAR COMBUSTION UNIT

Lorillard/A&T University

Lorillard uses low-pressure steam in its manufacturing processes and for space heating. Plant operations are basically 5 days per week, three shifts per day (with some steam demand for heating and cooling on the weekends). Although its steam requirements are continuous, this demand fluctuates dramatically by season, shift, and between weekday and weekend. Recent steam profiles indicate variations in steam demand ranging from a high of 40,000 pounds per hour (winter, daily first shift) down to below 10,000 pounds per hour (weekends). See Figure 4 for Lorillard's steam use profile. This steam demand represents a reduction in energy consumption from that used in 1979 when Lorillard was initially contacted as a potential buyer of waste-derived energy. In addition, the company's second- and third-shift steam use has become more variable since that time.

North Carolina A&T University uses steam for its hot water and cooking requirements and to meet its space-heating needs. This steam demand is continuous but varies significantly by season and hour of the day (see Figure 5).

As discussed earlier, because of the variability in demand of this steam market, cogeneration (the addition of a steam extraction turbine-generator set) was considered as a means of operating the system at a relatively constant steam load. As demand for steam slackens, the excess steam, rather than extracted for sale, is used to produce more electricity. The benefits of cogeneration are that energy recovery is maximized and a high system capacity utilization factor is achieved, resulting in maximum energy revenues to the project.

Two different sized cogeneration alternatives were considered for recovering energy for sale to this market. The first (Alternative 1) would have an average waste throughput of 625 TPD_7; Alternative 2 would be larger, with an average throughput of 1,000 TPD_7. Each is described below.

Alternative 1 would be either a mass-burning (two units, each with a design capacity of 375 TPD) facility or a coarse RDF/dedicated boiler facility. Waste would be supplied by the City of Greensboro only (approximately

FIGURE 4

LORILLARD - AVERAGE HOURLY STEAM USAGE

NOTE: First two columns in each month represent weekday use; third column represents weekends. Hourly swings can be ± 50% during winter.

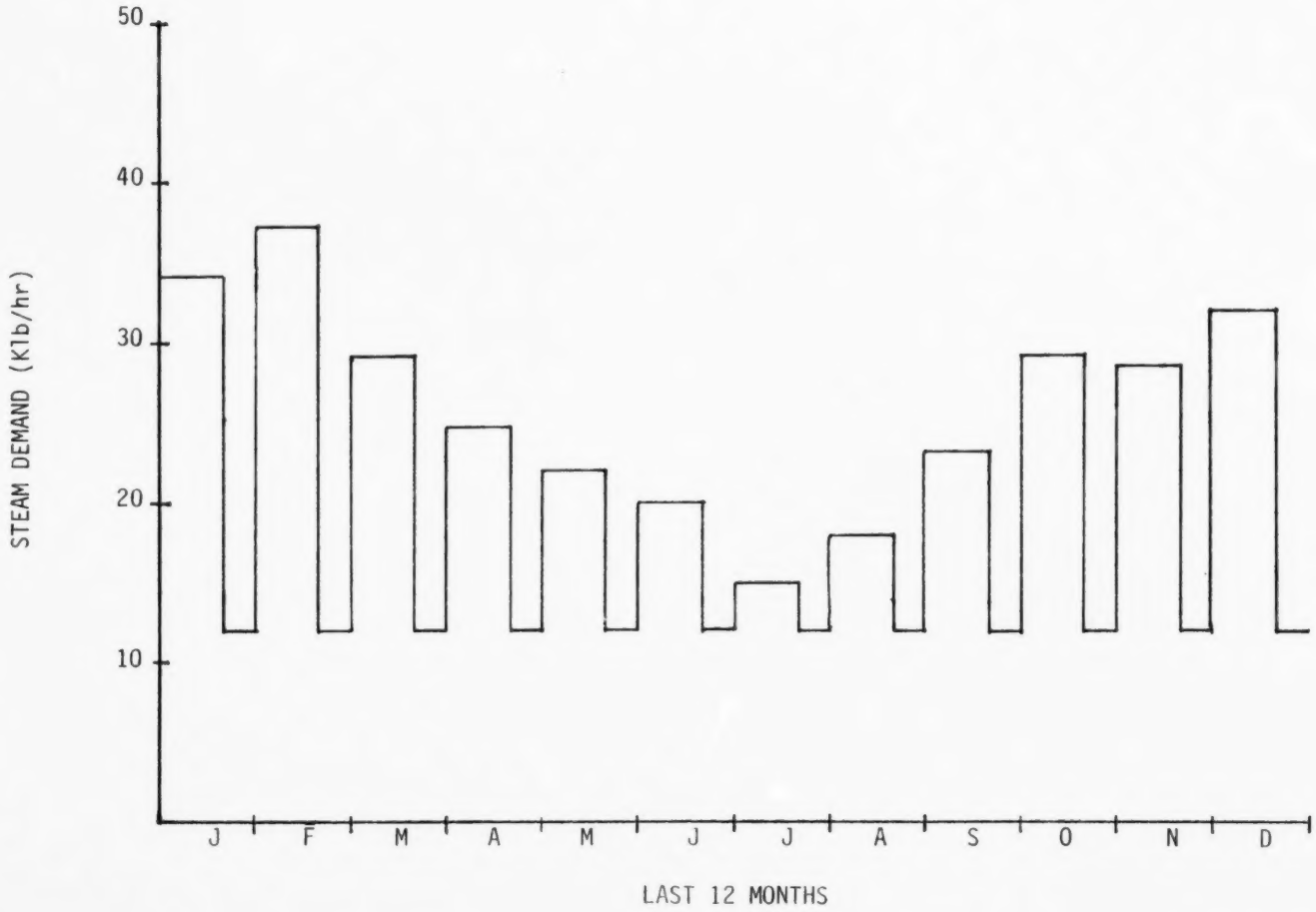
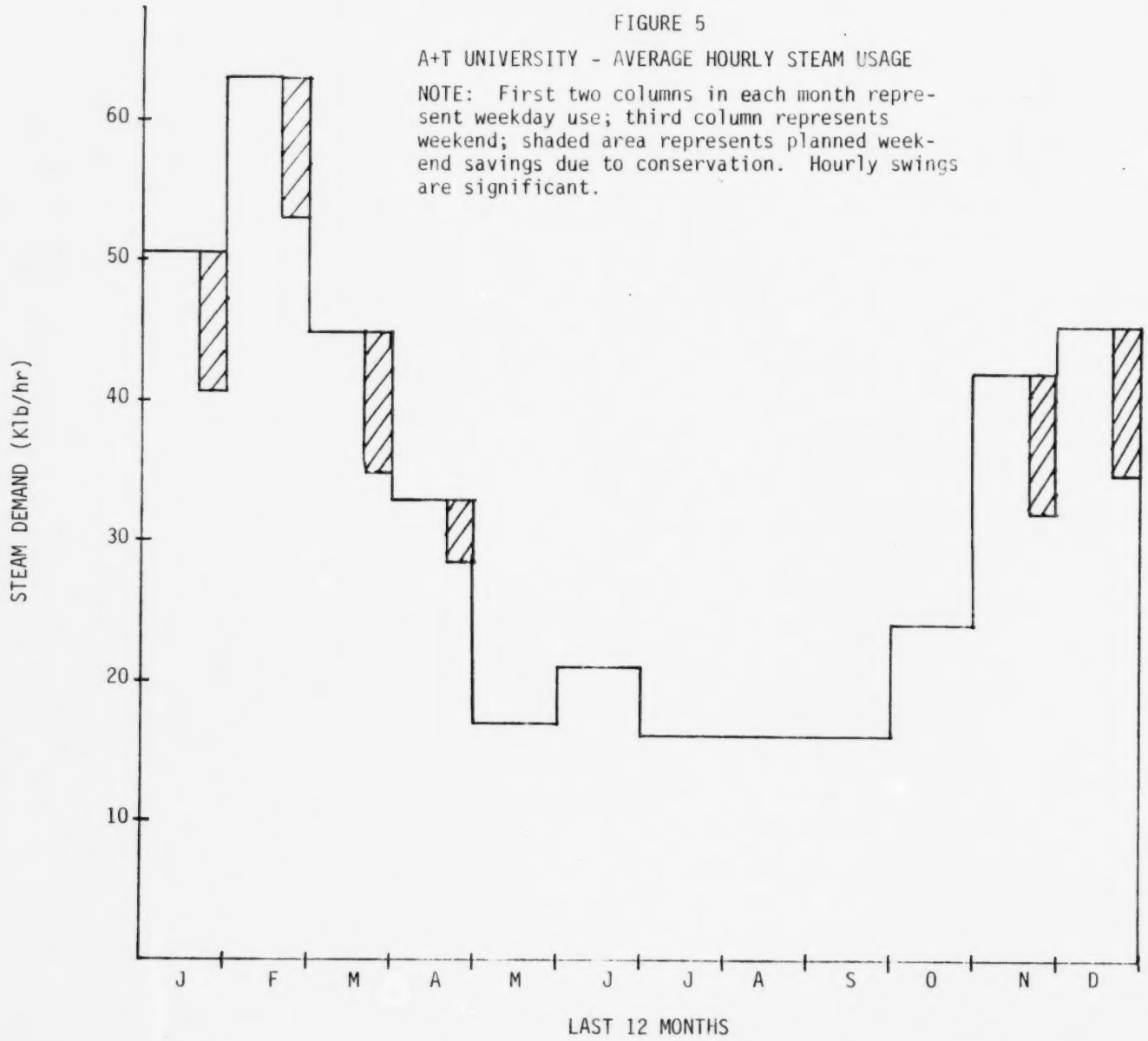


FIGURE 5

A+T UNIVERSITY - AVERAGE HOURLY STEAM USAGE

NOTE: First two columns in each month represent weekday use; third column represents weekend; shaded area represents planned weekend savings due to conservation. Hourly swings are significant.



624 TPD_7 of processible waste are estimated to be generated in Greensboro). A currently vacant 7-acre site contiguous to the Lorillard plant is potentially available for siting the energy recovery facility. High-pressure steam would be produced to drive an extraction turbine-generator set and generate electricity for sale to Duke Power, with exhaust steam extracted for sale to Lorillard and A&T University.* An approximately 1.2-mile steam transmission line would have to be constructed, running from the resource recovery plant at Lorillard to A&T University. Residues, unprocessibles, and emergency bypass waste would be disposed of at the existing Greensboro landfill.

Alternative 2 would be the same as described above, except that it would process a greater amount of waste (1,000 TPD_7). Two units, each with a design capacity of 600 TPD, would be used. The additional waste (some 375 TPD_7) would be obtained from either Winston-Salem or Winston-Salem and High Point, depending on the reliability of the waste generation estimates used in this study. (Processible waste generation estimates for Winston-Salem and High Point are 441 and 172 TPD_7, respectively.) As base-load steam requirements at Lorillard and A&T University would already be exceeded by the output of a 625-TPD_7 facility, all of the steam produced by this incremental waste in the larger 1,000-TPD_7 facility would be used to generate electricity.

Lorillard

Lorillard was also considered as an energy market independent of A&T University. Again, because of Lorillard's variable process steam demand, a cogeneration energy recovery concept was considered. Two alternatives were investigated: Alternative 3, a 249-TPD_5 MCU-based facility; and Alternative 4, an MCU-based facility, again with a 249-TPD throughput, except that it operates on a 7-day-per-week, rather than a 5-day-per-week, basis. Because these two alternatives are small-scale facilities, MCU technology was considered as experience has shown that this technology can provide better economics than can mass-burning technology for recovery

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* Electricity could possibly be sold to either Lorillard or Duke Power. For purposes of this analysis, electricity was assumed to be sold to Duke Power.

facilities at this scale. In both Alternatives 3 and 4, steam in excess of Lorillard's process steam demand would be used to generate electricity. This electricity would be sold to Duke Power. As these alternatives would be processing only a portion of the waste estimated to be available from Greensboro, the remaining processible waste would bypass the recovery facility and go directly to the existing Greensboro landfill (where plant residues, unprocessibles, and emergency bypass waste would also be disposed of).

Hanes

Hanes uses low-pressure steam in its manufacturing processes and for winter space heating. The plant operates on a 5-day-per-week, three-shift-per-day basis. A review of Hanes' most recent energy profile indicates that its steam requirements vary by season and by shift, ranging from 38,000 pounds per hour (winter, first shift) to about 5,000 pounds per hour (summer, third shift). Figure 6 gives the company's steam profile. This information indicates that the company has reduced its energy consumption, and that its process steam usage during the second and third shifts has become much more variable since originally interviewed in 1979. To meet Hanes' base-load steam requirements and still achieve a reasonable system capacity utilization factor, the concept of cogeneration was considered, where low-pressure steam would be sold to Hanes and electricity, to Duke Power.*

An MCU-based system (three 75-TPD units) with a steam extraction turbine-generator would be used to service this market. At maximum steam requirements of approximately 40,000 pounds, electricity production would be about 800 kWh; maximum electricity production would be 2,500 kWh, which would occur whenever steam demand fell below 15,000 pounds per hour. The energy recovery plant would operate 5 days per week with a throughput averaging 178 TPD_5.

This alternative would utilize a portion of the processible waste available from Winston-Salem and would be located on the site of the existing Rt. 5 landfill, which is contiguous to the Hanes manufacturing facility.

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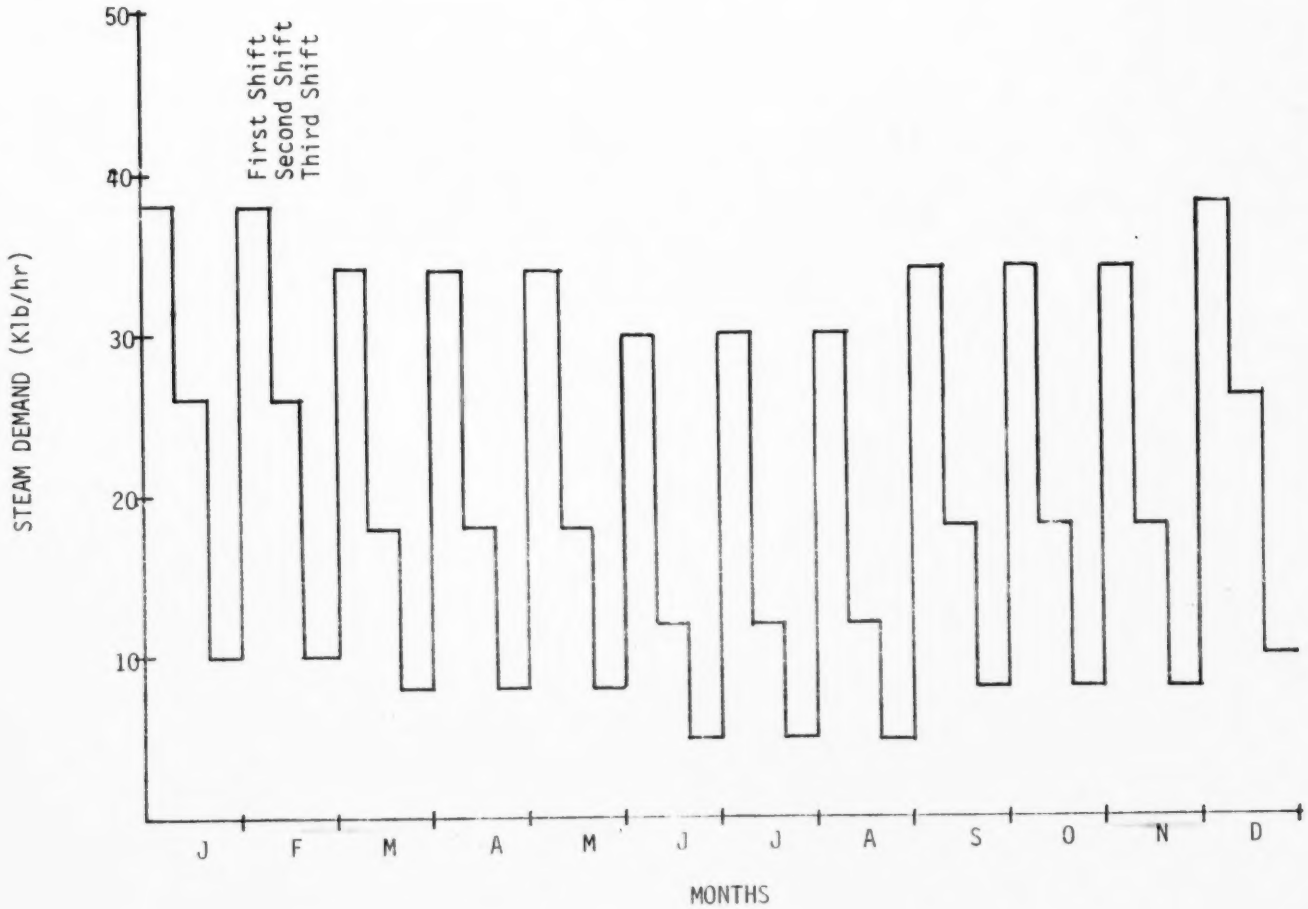
* Electricity could possibly be sold to either Hanes or Duke Power. For purposes of this analysis, it was assumed that electricity would be sold to Duke Power.

FIGURE 6

HANES CORP. - ESTIMATED HOURLY STEAM USAGE

NOTE: Three columns in each month represent average demand during each of three shifts, weekdays only.



The remainder of Winston-Salem's available waste, plant residues, unprocessibles, and emergency bypass waste would be transported to either of the two remaining Winston-Salem landfill facilities for disposal.

Greensboro Waste Water Treatment Complex

The City of Greensboro, in conjunction with Guilford County, is building an advanced wastewater treatment facility on a site adjacent to the city's solid waste shredding operation. This complex is scheduled to become operational in 1983 and will require electricity on a continuous basis, 365 days per year, 24 hours per day. Based on preliminary engineering estimates, this facility will consume 36 million kW annually or approximately 4,000 kWh.

In the absence of a nearby steam customer, consideration was given to the concept of straight electricity production for sale to the complex. Alternative 6 represents a resource recovery system sized to meet the projected electricity requirements of the complex. This alternative is an MCU-based system (five 75-TPD units) coupled with a turbine-generator set. Located contiguously to the proposed complex, this plant would operate 7 days per week with an average throughput of 310 TPD_7. The remainder of Greensboro's waste, as well as emergency bypass waste, unprocessibles, and plant residues, would be transported to the existing Greensboro landfill for disposal.

ECONOMIC ANALYSIS OF RESOURCE RECOVERY ALTERNATIVES

The six resource recovery alternatives identified as technically feasible in the previous analysis were also evaluated to determine their economic practicality. As a result of this analysis, it was found that no economically practical projects exist for High Point; two projects appear promising for Greensboro; and, depending upon Hanes' willingness to modify its second- and third-shift steam requirements in response to waste-derived steam offered at a significant discount, one project may exist for Winston-Salem. None of these projects would process all of the waste estimated to be available in the affected community. The general advantages and disadvantages of those projects appearing to be economically practical were then compared.

ECONOMIC PRACTICALITY

To be considered economically practical, a resource recovery project must offer a net solid waste disposal cost ($/ton) that is competitive with the cost of continued landfilling. The net solid waste disposal cost is estimated by subtracting the energy revenues for the project from the capital and operating and maintenance (O&M) costs associated with the resource recovery facility and the backup landfill. This estimate is then divided by the tons processed annually to obtain an estimated cost in $/ton.

To determine the economic practicality of the six alternatives, the net disposal cost of each alternative was projected for the assumed 1st and 6th years of facility operation. Although life-cycle costing is an appropriate method of economic analysis for resource recovery systems, the difficulty of projecting costs and revenues over the life of a facility (15 years or greater) limited the projections to the first 6 years.

The projected net disposal costs of the six resource recovery alternatives were compared with the projected costs of continued

landfilling. The results of this economic evaluation indicate that only three of the six resource recovery facilities appear to be economically practical:

1. Alternative 3, a 249-TPD_5 MCU system using a portion of Greensboro's waste to produce process steam for Lorillard and electricity for Duke Power.

2. Alternative 4, a 249-TPD_7 MCU system using a portion of Greensboro's waste to produce process steam for Lorillard and electricity for Duke Power.

3. Alternative 5, a 178-TPD_5 MCU system using a portion of Winston-Salem's waste to produce process steam for Hanes and electricity for Duke Power.

To date, revenue bonds and general obligation bonds have been the principal instruments used for financing resource recovery projects. However, because of the tax benefits afforded to the investor, equity investment in a resource recovery project is becoming more common. Because each resource recovery alternative would be competing against the projected relatively low cost of continued landfill disposal, and because energy revenues would suffer to the extent that lower priced electrical energy would be produced instead of steam, it was critical to minimize the capital costs for each alternative to the greatest extent possible. For these reasons, the economic analysis assumed that an equity contribution of approximately 25 percent of the projected capital costs would be available from the system vendor, project developer, or energy customer. Hence, all alternatives, except Alternative 6, assumed a 25-percent equity/75-percent industrial revenue bond (IRB) financing approach. In the case of Alternative 6, the Greensboro Waste Water Treatment Complex, a 100-percent municipal revenue bond financing was assumed.

Table 1 summarizes the projected net disposal cost for each of the six resource recovery alternatives for the 1st and 6th years of operations. Because Alternative 4 appears to provide more favorable economics than Alternative 3, more detailed economic estimates are only presented for the former, as both alternatives would service

TABLE 1

SUMMARY OF STUDY LEVEL COST ESTIMATES FOR

RESOURCE RECOVERY ALTERNATIVES FOR THE TRIAD AREA

Alternative	Location	Energy Products	Primary Energy Markets	Technology	Design Capacity/ Average Daily Throughput	Projected Net Disposal Cost ($/Ton) 1st Yr.	6th Yr.
1	Greensboro	Steam and Electricity	Lorillard and A&T University	Mass-burning or coarse RDF*	750/625 TPD_7	27	17
2	Greensboro	Steam and Electricity	Lorillard and A&T University	Mass-burning or coarse RDF*	1200/1000 TPD_7	30	25
3	Greensboro	Steam and Electricity	Lorillard	MCU	300/249 TPD_5	14	5
4	Greensboro	Steam and Electricity	Lorillard	MCU	300/249 TPD_7	8	1
5	Winston-Salem	Steam and Electricity	Hanes	MCU	225/178 TPD_5	17 9**	11 2**
6	Greensboro	Electricity	Greensboro Wastewater Treatment Complex	MCU	375/310 TPD_7	23	24

* Recent experience with other resource recovery projects indicates that the capital and O&M costs of comparably sized mass-burning and RDF/dedicated boiler technologies are likely to be similar. For purposes of this analysis, mass-burning has been used as representative of the costs of both systems. The ultimate choice between the two technologies can only be made after detailed analysis.

** These cost projections assume Hanes modifies its second- and third-shift operations in response to waste-derived steam offered at a 50-percent discount.

the same market and city. Tables 2-5 summarize the capital cost projections and O&M estimates for the two most promising options (Alternatives 4 and 5).

Projected System Costs

The 1981 capital cost estimates for mass-burning and MCU systems were developed from preliminary engineering estimates and recent bids submitted by full-service vendors for comparable resource recovery systems. These estimates were then projected to 1983 and 1984 (assumed to the the midpoint of construction for the MCU and mass-burning alternatives, respectively), at a compounded annual rate of 10 percent. Under the assumption of combined equity/IRB financing, the 25-percent equity contribution enables reductions in the debt service reserve and capitalized interest accounts and reduces the total bond issue by approximately $1.30 for each dollar of equity invested, resulting in a significantly reduced annual debt service component.

Revenue Projections

In projecting energy revenues, the following assumptions were made:

- The price of the facility's steam output reflects, on a Btu-equivalent basis, the price of the fuel displaced, less a 10-percent discount to the energy customer.*
- Natural gas price is deregulated and achieves parity with a 1-percent sulfur No. 6 oil by 1984. The price of No. 6 oil (70¢ per gallon in February 1980) escalates at a compounded annual rate of 10 percent from 1980 through 1988.**

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* A separate case was analyzed for Hanes where waste-derived steam would be sold at a 50-percent discount during the company's second and third shifts.

** On the basis of information available, it appears as though natural gas prices will be deregulated. In the event that deregulation does not occur, the projected energy revenues obtained from the displacement of natural gas would probably be lower.

TABLE 2

ALTERNATIVE #4: 249-TPD$_7$ MCU SERVING LORILLARD
REVENUE BOND SIZING @ 25% EQUITY/
75% REVENUE BOND FINANCING*

		1982 Bond Issue ($000)
A.	Capital Costs	10,406
B.	Contingency @ 10% Item A	1,041
C.	Startup/Testing/Acceptance	650
D.	Management/Financial/Legal Consultant	250
	SUBTOTAL	12,347
E.	Equity Financing @ 25% Items A-D	(3,087)
F.	Capitalized Interest during Construction/Startup	1,137
G.	Debt Service Reserve Fund	1,533
H.	Financing Costs @ 3% Item I	370
I.	Total Bond Issue	12,300
TOTAL FINANCING		15,387**

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* Assumes 1984 is the beginning of the first year of full-scale resource recovery plant operations.

** Due to rounding, totals are not exact.

TABLE 3

ALTERNATIVE #4: 249-TPD_7 MCU SERVING LORILLARD

STUDY LEVEL ESTIMATES OF ANNUAL COSTS AND REVENUES

@ 25% EQUITY/75% REVENUE BOND FINANCING ($/TON)

		YEAR				
OPERATING COSTS	(1984) 1	2	3	4	5	6
Debt Service Payment	17.11	17.11	17.11	17.11	17.11	17.11
O&M Costs*	16.44	17.92	19.53	21.29	23.21	25.29
Residual Disposal Costs	3.35	3.69	4.05	4.46	4.90	5.40
TOTAL	36.90	38.72	40.69	42.86	45.22	47.80
REVENUES						
Interest	2.05	2.05	2.05	2.05	2.05	2.05
Energy**	26.54	29.46	32.70	36.30	40.29	44.72
TOTAL	28.59	31.51	34.75	38.35	42.34	46.77
PROJECTED NET DISPOSAL COSTS OF RESOURCE RECOVERY	8.31	7.21	5.94	4.51	2.88	1.03
PROJECTED NET DISPOSAL COST OF CONTINUED LAND-FILLING	9.35	10.29	11.31	12.44	13.69	15.06

* Includes operator's profit.

** Assumes 10% discount to steam customer. Electricity is sold to Duke Power with no discount.

TABLE 4

ALTERNATIVE #5: 178-TPD$_5$ MCU SERVING HANES

REVENUE BOND SIZING @ 25% EQUITY/

75% REVENUE BOND FINANCING*

		1982 Bond Issue ($000)
A.	Capital Costs	7,100
B.	Contingency @ 10% Item A	710
C.	Startup/Testing/Acceptance	650
D.	Management/Financial/Legal Consultant	250
	SUBTOTAL	8,710
E.	Equity Financing @ 25% Items A-D	(2,180)
F.	Capitalized Interest during Construction/Startup	800
G.	Debt Service Reserve Fund	1,080
H.	Financing Costs @ 3% Item I	260
I.	Total Bond Issue	8,665
TOTAL FINANCING		10,845

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* Assumes 1984 is the beginning of the first year of full-scale resource recovery plant operations.

** Due to rounding, totals are not exact.

TABLE 5-A

ALTERNATIVE #5: 178-TPD_5 MCU SERVING HANES

STUDY LEVEL ESTIMATES OF ANNUAL COSTS AND REVENUES

@ 25% EQUITY/75% REVENUE BOND FINANCING ($/TON)

		YEAR					
OPERATING COSTS	(1984)	1	2	3	4	5	6
Debt Service Payment		23.38	23.38	23.38	23.38	23.38	23.38
O&M Costs *		20.13	21.94	23.92	26.07	28.42	30.97
Residual Disposal Costs		3.04	3.34	3.68	4.05	4.45	4.90
TOTAL		46.55	48.66	50.98	53.50	56.25	59.25
REVENUES							
Interest		2.81	2.81	2.81	2.81	2.81	2.81
Energy **		27.18	30.17	33.49	37.17	41.26	45.80
TOTAL		29.99	32.98	36.30	39.98	44.07	48.61
PROJECTED NET DISPOSAL COSTS OF RESOURCE RECOVERY		16.56	15.68	14.68	13.52	12.18	10.64
PROJECTED NET DISPOSAL COST OF CONTINUED LANDFILLING		7.15	7.87	8.65	9.52	10.47	11.52

* Includes operator's project.

** Assumes 10% discount to steam customer.
Electricity is sold to Duke Power with no discount.

TABLE 5-B

ALTERNATIVE #5: 178-TPD_5 MCU SERVING HANES

STUDY LEVEL ESTIMATES OF ANNUAL COSTS AND REVENUES

@ 25% EQUITY/75% REVENUE BOND FINANCING ($/TON)

OPERATING COSTS	(1984)	YEAR 1	2	3	4	5	6
Debt Service Payment		21.70	21.70	21.70	21.70	21.70	21.70
O&M Costs*		20.13	21.94	23.92	26.07	28.42	30.97
Residual Disposal Costs		3.04	3.34	3.68	4.05	4.45	4.90
TOTAL		44.87	46.98	49.30	51.82	54.57	57.57
REVENUES							
Interest		2.50	2.50	2.50	2.50	2.50	2.50
Energy**		33.06	36.87	40.00	44.00	48.40	53.24
TOTAL		35.87	38.87	42.50	46.50	50.90	55.74
PROJECTED NET DISPOSAL COSTS OF RESOURCE RECOVERY		9.31	8.11	6.80	5.32	3.67	1.83
PROJECTED NET DISPOSAL COST OF CONTINUED LANDFILLING		7.15	7.87	8.65	9.52	10.47	11.52

* Includes operator's project.

** Assumes 10% discount to steam customer for 1st-shift steam; 50% discount for 2nd- and 3rd-shift steam. Electricity is sold to Duke Power with no discount.

Cost of Continued Landfilling

The cost of continued landfill disposal was projected to 1989, based on 1978 cost data previously submitted. Cost escalations of 10 percent compounded annually were assumed, resulting in 1st year (1984) costs of continued landfilling of $9.35 per ton for Greensboro and $7.15 per ton costs for Winston-Salem. Sixth year costs (1989) are projected at $15.06 and $11.52, respectively.

COMPARISON OF FEASIBLE PROJECTS

To complete the evaluation of the resource recovery alternatives, the advantages and disadvantages of the two alternatives identified as most promising were identified.

Alternative 4. This 249-TPD_7 MCU system would utilize a portion of the estimated 624 TPD_7 of processible waste available from Greensboro to produce process steam for Lorillard and electricity for Duke Power.

The major advantages of this option are:

- A likely reduction in costs of disposal to the City of Greensboro.
- An extension of the useful life of the existing Greensboro landfill by 25 to 30 percent.
- Provision of a secure source of competitively priced energy to a major local industry.

The disadvantages of this option include:

- Dependence on partial equity financing by system vendor, developer, or energy customer to ensure economic viability.
- Waste processing capacity limited to a portion of the city's available waste supply.

Alternative 5. This 178-TPD_5 MCU system utilizes a portion of Winston-Salem's estimated 624 TPD_5 of available processible waste to produce process steam for Hanes and electricity for Duke Power.

The major advantages of this option are that it:

- Has the potential to result in reduced costs of disposal for the city.
- Affords an opportunity to consolidate disposal operations by closing one of three existing disposal facilities.

Major disadvantages include:

- Economic attractiveness depends on increased second- and third-shift steam demand at Hanes in response to a 50-percent discount on steam.
- Dependence on partial equity financing by system vendor, developer, or energy customer to ensure economic viability.
- Waste processing capacity limited to a portion of the city's available waste supply.